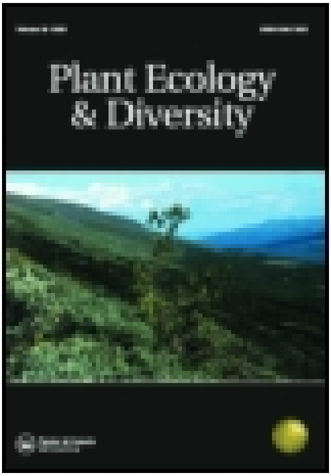

Transactions of the Botanical Society of Edinburgh

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tped18

The Latent Life of Plants

R. A. Robertson M.A. B.Sc. [a]

[a] F.R.S.E.

Published online: 29 Nov 2010.

To cite this article: R. A. Robertson M.A. B.Sc. (1905) The Latent Life of Plants, Transactions of the Botanical Society of Edinburgh, 22:1-4, 178-191, DOI: 10.1080/03746600509480342

To link to this article: http://dx.doi.org/10.1080/03746600509480342

exhibits so high a degree of suggestibility. The child-mind maintains for so short a time, and in so slight a fashion, any one course of action or set purpose, that almost any fresh idea (suggestion) from parent or play-mate can divert it into a fresh channel, and the new idea, in turn, can be easily supplanted by some other notion newer still. There is so little inertia of position belonging to the idea in possession of the mind that the idea can be very easily supplanted, and the new idea has so little momentum that it can be at once turned out of its course by some new thing. Thus a volatile nature is one with but slight mental inertia of movement; a "dogged" temperament is one with much. The great obstinacy of the uncultured, and the "fixed delusion" of the lunatic are cases of excessively developed inertia of psychic rest. Surely psychic anabolic inertia is responsible for the lack of correspondence between sensation and stimulus as formulated in the Weber-Fechne law; certain increments of stimulus *not* giving rise to any increase of sensation until certain intensity-limits are passed. The insusceptibility that exists through a whole series of increments of stimulus, from the last sensation-producing increment to the next one, seems one more instance of psychic inertia. Lastly, the differences in duration of reaction-time ("personal equation") between various kinds of people are directly due to the differences in degree of the psychic anabolic inertia of their cerebral cells.

The graphic record of reaction-time gives us a measure in fractions of a second of the degree of their cerebral anabolic inertia, but their whole characters are a daily and familiar exposition of psychic inertia of rest or of activity respectively.

THE LATENT LIFE OF PLANTS.

By R. A. ROBERTSON, M.A., B.Sc., F.R.S.E.

(Read 13th February 1902.)

The manifestation of plant life depends on certain external conditions, and in reference to these it is usual to make a distinction between the tonic and the stimulant effects. That particular combination of influences necessary to induce and maintain growth is regarded as tonic, while any variation in these conditions produces growth variations, and is described as stimulant. It has to be remembered, however, that the difference here pointed out is, after all, one of degree and not of kind. From this point of view plant growth is a continuous manifestation of irritability, and it is this power of responding, of manifesting irritability that, in the first instance, enables us to distinguish between a living and a dead organism.

We take a stimulus here in its widest sense, as defined by Pfeffer ("Physiology," p. 11), as "a push to which the organism responds according to its inherent nature and the means at its disposal," while any result immediately accruing or appearing only after days or weeks have elapsed is a manifestation of irritability.

When a motor stimulus is applied to resting plant protoplasm, as is well known, an interval of time elapses before the movement begins; and conversely, when the stimulus is one to inhibit a movement already in progress, a corresponding interval passes before inhibition. These intervals are the familiar latent periods, and it is during these periods that the protoplasm exhibits its property called functional inertia (Harris, Brit. Med. Assoc., Aug. 1900). In the first case, it is functional inertia of anabolism; in the second, that of katabolism. One or other is always in evidence after a stimulus, and in many cases both, following in the order either of (1) anabolism, (2) katabolism, or the reverse. Plant physiology supplies copious examples of both phases.

External influences are efficient as growth stimuli only when they are applied within definite limits of intensity. We have thus to recognise the existence of stimulatory limits, maxima and minima. The protoplasmic molecules have their own limit of swing and rate of vibration, and no amount of pushing, *i.e.* of stimulation, will induce them to swing farther or faster. At the outset we are met with a "refractory period"—a non-responsiveness of living matter beyond certain limits. This is the expression of its functional inertia.

We take up seriatim cases of plant irritability with the view of exhibiting this interesting property in its many varied aspects.

Gravity.—When a stem laid horizontally continues to grow in the same direction for some time before curving geotropically it exhibits functional inertia of anabolism. The time value of the inertia varies for different members, from a few minutes (Darwin, "Nature," vol. 65 p. 44) to an hour or more (Detmer, "Physiology," p. 443). When the shoot curves past the vertical—the point of zero stimulation,—the other phase of katabolic inertia is presented. This is, to use Harris's analogy, the door swinging after you have ceased to push it. In those cases where a sense organ has been proved to exist (Pfeffer, "Annals of Botany," viii. p. 317, and Darwin, "Annals of Botany," vol. xii. p. 567), from which the impulse is transmitted to a responsive organ, transmission time—including Czapek's exposition and presentation period—has to be deducted from the reaction time to obtain the time value of the inertia.

To place an upright support in the way of a twiner whose movement is due in part at least, if not entirely, to lateral geotropism, is a case of mechanically inhibiting a movement. If the support be removed before growth has rendered the curvature permanent, the revolving movement recommences, but only after a latent period, varying from a few hours to a few days (Darwin, "Climbing Plants," p. 21). This is katabolic inertia.

Light and darkness.—Light acts as a stimulus in virtue of its intensity and also of the direction of its incident rays. A plant which has been growing rapidly during the night does not have its growth retarded immediately on the approach of daylight, nor when placed in darkness after being exposed to light is its growth immediately accelerated. In both cases, for an hour or more (Sach's "Physiology," p. 559; Vines' "Physiology," p. 395), in virtue of the functional inertia of the protoplasm, the previous conditions continue, and the growth curve continues to rise in the first instance and to fall in the second.

When *Bacterium photometricum* (Vines' "Physiology," p. 523) is placed in darkness its movements are inhibited, and when brought into light they recommence, but in neither case is the manifestation of irritability immediate. In the first instance, there is a period of katabolic, and in the latter of anabolic inertia, and the time values of these periods vary with the intensity of the light.

Concentrated sunlight will inhibit the streaming of protoplasm of *Elodea* after five to six minutes, while recovery takes place in fifteen minutes to an hour (Ewart, "Annals of Botany," xii. p. 385). Here we have both phases, first the katabolic and then the anabolic.

When CO_2 assimilation in *Elodea* has been inhibited by prolonged darkness, the recovery on exposure to light requires from twenty minutes to half an hour (Darwin, "Proc. Camb. Phil. Soc.," ix. 338). This is the expression of the katabolic inertia.

In what Wiesner calls photo-mechanical induction of heliotropic heterauxesis, we have interesting cases where the functional inertia amounts to a *physiological insusceptibility.* Thus, in order to induce the maximum heliotropic curvature a definite time exposure is necessary, and no additional exposure will cause the organ to curve farther or faster. For the cress and vetch, Wiesner (Vines' "Physiology," p. 435) found the period of photo-mechanical induction to be about one-third of the reaction period, *i.e.* something over eight minutes for the former and under twelve minutes for the latter. Following this came the period of anabolic inertia lasting from twenty-five to thirty-five minutes, after which curvature began.

A parallel case is presented in Lewes' researches ("Annals of Botany," vol. xii. p. 420) on the movements of the chloroplast of *Mesocarpus.* Lewes found that a definite time exposure—one and a half minute in sunlight and two minutes in diffuse light—was necessary to bring about the greatest possible movement of the chloroplast, viz. rotation through 90°. Further, a definite time was necessary for the performance of the movement, viz. half an hour in the first instance, and twenty minutes in the latter. This supplies a very lucid demonstration that the protoplasmic molecules have their own rate and extent of swing, and are not to be induced to pass it. It is the case of the free wheel bicycle pedal, which no amount of pushing will cause to pass the dead point—the dead point here being the horizontal for diffuse light and the vertical for sunlight.

Under this category also come cases of attunement of Algæ to light of particular intensity (Detmer, "Physiology," p. 426).

Temperature.—Temperature variations induce growth variations in the course of a few hours. This period of anabolic inertia is relatively short when contrasted with that following variations in the other tonic conditions, such as pressure of oxygen or food supply (Pfeffer, "Physiology," pp. 511, 512). A rise of temperature from 15°–20° C. stimulates tulip and crocus flowers to open after a latent period—anabolic phase—of five minutes or so. If while opening the temperature be reduced, they close, but not immediately; in virtue of their katabolic inertia they continue to open for a few minutes. Pfeffer states that the tulip is sensitive to a difference in temperature of $\frac{1}{2}$° C, while the crocus to 2° or 3° C. The former thus has much less functional inertia to change of temperature than the latter.

At 46° C., protoplasmic streaming is inhibited in *Elodea* after the short period of two minutes—katabolic inertia—while recovery requires 1–2 hours, a relatively prolonged period of anabolic inertia (Detmer, "Physiology," p. 420).

In response to the directive stimulus of the heat rays, *Lepidium* seedlings execute negative thermotropic curvatures, while *Zea* seedlings exhibit positive thermotropism. In both cases the curvature begins only after the lapse of a few hours—anabolic inertia.

Contact.—Taking cases of contact irritability as exemplified in tendril climbers, insectivorous, and sensitive plants, we find that they display functional inertia under varied aspects, *e.g.* phenomena of latent and refractory periods, physiological insusceptibility, and specific idiosyncracy. In the different species of *Drosera* the latent period varies from ten seconds to twenty minutes (Darwin, "Insectivorous Plants"), while in the tendrils of the *Passifloreæ* it may be from a few seconds to an hour (MacDougal, "Annals of Botany," vol. x. p. 373). In contrast to the above, *Dionæa* and *Mimosa* have relatively so little anabolic inertia that the response to contact appears immediate. On the other hand, the tendrils of the *Ampelideæ*, with relatively little irritability, display much anabolic inertia, the latent period lasting for two hours or more.

Cases of physiological insusceptibility appear in relation to particular amounts of stimulus. Thus, while a single light touch elicits a response in *Mimosa*, for *Dionæa* it has to be repeated, *i.e.* a kind of double impact is necessary, according to Macfarlane. *Drosera*, on the other hand, exhibits a refractory period, inasmuch as the efficient stimulus is a continued series of such impacts, *i.e.* a pressure; while in tendrils, according to Pfeffer, the stimulus is contact with a rough surface, *i.e.* a series of impacts simultaneously applied at discrete points of the sensitive organ.

Injury.—Cases of traumatic stimulation are instructive both on account of the varied manifestation of irritability and of the great range in the time value of the latent period. This, as we find, may vary from a few seconds to as much as a week, and in some cases may be artificially prolonged to eight days.

If we take fertilisation as a case of stimulation (Pfeffer, "Physiology," p. 55), we may regard it as of a chemico-vital and traumatic character. Thus, as the spermatozoid breaks the continuity of the plasmatic membrane, and ploughs its way through the cytoplasm, we find as reaction to the traumatic stimulus the formation of a protective cell-wall on the egg. This takes place after a period of anabolic inertia varying from ten minutes in *Fucus* (Farmer and Williams, "Phil. Trans. Roy. Soc.," 1898, p. 625) to a few hours in other forms.

Again, a cell membrane may appear around a plasmolysed protoplast after fifteen minutes—or more—period of anabolic inertia (Pfeffer, "Physiology," p. 483).

Injury to the maize epidermis stimulates protoplasmic streaming after fifteen minutes to an hour (Detmer, "Physiology," p. 420). Lateral injury to the root apex induces traumatropic curvature and regeneration of the root tip after a latent period of an hour or so (Spalding, "Annals of Botany," viii. p. 423). By encasing the root in a plaster-cast, or lowering the temperature, the curvature is prevented, and the anabolic period may be prolonged for eight days. A fever reaction is induced in massive tissues, as potato tubers, by incised wounds after a reaction period of two hours or so (Richards, "Annals of Botany," x. p. 531, and xi. p. 29). According to Townsend ("Annals of Botany," xi. p. 515), amputation of a small piece of the root apex is followed after a latent period of twenty-four hours by a retardation of growth in the root and an acceleration of growth in the stem. The long latent period of five or six days elapses between the application of the traumatic stimulus and the manifestation of irritability—a peculiar healing reaction—in isolated leaves of *Prunus lauro-cerasus* (Blackman and Matthaei, "Annals of Botany," xv. p. 533).

Oxygen.—Absence of free oxygen inhibits streaming in *Chara*, but only after a considerable period of katabolic inertia (Ewart, "Jour. Lin. Soc.," xxxi. p. 421 ; also Farmer, "Annals of Botany," x. p. 286), while obligate aerobia continue to move from five to sixty minutes in the absence of free oxygen (Pfeffer, "Physiology," p. 569).

The list of examples might be indefinitely extended. Interesting cases of physiological insusceptibility are supplied in Arber's researches on the CO_2 assimilation of halophytes ("Annals of Botany," xv. pp. 39 and 669), in the thermo-secretory phenomena of nectaries (Pfeffer, "Physiology," p. 286), in Pfeffer's "Chemotactic Application of the Weber-Fechner Law," in the vital phenomena of parasites, fungal and other. On the other hand, Ewart's researches on assimilatory inhibition ("Jour. Lin. Soc.," xxxi. pp. 364, 554; "Annals of Botany," xi. p. 439) are a mine of examples of both phases of functional inertia. In many cases the biological significance of the time-value of the functional inertia is of the highest importance. Thus (Ewart, "Annals of Botany," xii. p. 378) mosses have much katabolic inertia to desiccation, and relatively little anabolic inertia to moisture; they continue to assimilate for two to five days during desiccation, and when desiccated they resume operations on moisture being supplied in the short period of a few hours. The same is true of other members of Alpine floras, and the importance of it is manifest.

Passing on to consider the functional inertia of excised and isolated organs, we again find no lack of examples, in consequence of the lower pitch of vitality and greater individuality of plant protoplasts. As the wheel continues, in virtue of its inertia of motion, to rotate, it may be for a considerable time after the driving gear is slipped, so many plant organs and cell organoids continue to function for a time when isolated. This is a manifestation of their katabolic inertia. Isolated chloroplasts, for example, assimilate for five hours (Ewart, "Jour. Linn. Soc.," xxxi. p. 420); isolated endosperm of *Ricinus* lives and carries on metabolic change for six months (Van Tieghem, "Ann. d. Sc. Nat.," 1876, Ser. vi., T. iv., p. 183), a fact which may be of interest in connection with xenia and double fertilisation. Isolated scutellar epithelium secretes enzymes and corrodes starch grains (Brown and Morris, "Jour. Chem. Soc. Trans.," vol. lvii., 1890, p. 494). Isolated fragments of swarmspores move, and of cytoplasm stream, while Demoor found that nuclei continued their mitosis after the cytoplasm was killed by CO_2 or chloroform (Pfeffer, "Physiology," p. 52). Again, isolated leaves of *Drosera* continue active, translocation takes place in heads of cereals (Pfeffer, *loc. cit.* p. 585), and ripening in fruits after separation from the parent plant; and oak galls continue their internal metabolic changes when removed from the tree (MacDougal, "Physiology," p. 64).

In the consideration of rhythm or periodicity we again meet with interesting examples of inertia. Thus, in virtue of their functional inertia, plants continue to exhibit daily periodicity of growth for periods varying from two days to as many weeks in continuous darkness. Some trees, like the oak and beech of temperate regions, which exhibit a seasonal periodicity, retain that periodicity when removed to countries where the vegetation is evergreen; they do so in consequence of their great amount of inertia. Other temperate trees, again, possessed of a smaller amount of inertia, lose their periodicity after a time and become evergreen, *e.g.* the plum and the peach. On account of possessing relatively little inertia, again, some plants will "force" and flower out of season, others with more inertia are refractory. By cold storage—artificially keeping the plant in a condition of anabolic inertia—the refractoriness of the latter may be in some measure overcome.

Plants which have a daily periodicity of movement, such as sensitive plants, daisy, and so forth, exhibit post-stimulant periodic movements in continuous darkness. This is one expression of their functional inertia.

Evidence on similar lines can be adduced from the interesting experiments of Darwin and Pertz ("Annals of Botany," vol. vi. p. 425), and others, on induced rhythm in different organs.

Polarity, according to Detmer ("Physiology," p. 507), may be regarded as an "after effect phenomenon induced by gravitation and stretching beyond the life of the individual, as a phenomenon of inherent or stable induction, and therefore an inheritable disposition." For the more or less indelible impression of this character by summation of effects, the property of functional inertia would be a necessary preliminary. On account of their greater functional inertia, polarity is more indelibly stamped on some plants than on others, and in the latter, in consequence of their smaller degree of inertia, it is possible to alter the polarity by the influence of external conditions. It would seem that in the acquirement of characters generally by living matter, *i.e.* in the "education" of protoplasm, functional inertia is a factor of great importance.

The time taken for summation of effects, for the education or acquirement of characters, will depend on the amount of inertia displayed by the protoplasm in relation to the particular stimulus. Time is an element of the process, and this represents the time value of the functional inertia. The following cases might be cited as bearing on this point in particular, but additional examples will present themselves to every botanist.

Stahl ("Bot. Zeit.," 1884), by gradually adding glucose to water in which *Æthalium* plasmodium was growing, succeeded in growing it ultimately in a 2 per cent. solution, which would, under ordinary circumstances, have killed it.

It is a well-known fact that sporeless and other varieties of bacteria may be obtained by continued cultivation in particular nutrient solutions under special conditions.

Again, it has been pointed out that some plants can be acclimatised, but others not at all; the former have relatively little inertia as compared with the latter.

Protoplasm can be gradually acclimatised to an atmosphere of 1 part oxygen to 4 of CO_2, which, when directly applied, inhibits all movement (Lopriore; MacDougal, "Physiology," p. 57).

Consideration of these cases of single stimuli makes it clear that plant protoplasm has not always the same amount of functional inertia, and further, that the time value of the inertia varies very widely in different organs in respect of the same stimulus. Thus it ranges from periods of time measured by seconds to hours or days, and it has been indicated that it is possible to artificially lengthen the period. There still remain to be considered those cases where the amount of inertia is so considerable that more than one stimulus is necessary to elicit a manifestation of irritability, and where, furthermore, the inertia assumes the character of a physiological insusceptibility, inasmuch as the reaction is only called forth by a particular combination of stimuli.

Pierce ("Proc. Calif. Acad. Sc.," Ser. III. ii., 1901, p. 83, also "Bot. Central. Bd.," lxxix., 1902, p. 36) describes a case of redwood stumps producing white suckers. No chlorophyll was developed, according to Pierce, because of the low inhibitory temperature; the shoots were parasitic on the underground parts of the tree. The temperature rose, and the inhibitory was replaced by an inducing stimulus, but yet no chlorophyll was developed. From our point of view the plants were thus manifesting great functional inertia of anabolism. Only when a second stimulus came into action (a change in the food conditions) was there a response in the production of green leaves. The anabolic inertia was here so great that *two* stimuli of a tonic character, conditions of temperature and food supply, were required to elicit the manifestation of irritability.

A more extreme case still is furnished in the winter buds of *Hydrocharis*. Terras found ("Trans. Bot. Soc. Edin.," xxi., 1900, p. 318) that if covered up these buds could be kept in the dormant condition, that is in a condition of anabolic inertia, for at least *two* years. To induce germination, heat, light, and oxygen were necessary. So great was the anabolic inertia that *three* stimuli of a tonic character were required to elicit a manifestation of irritability, in this case—growth.

This example forms a transition to the condition of the dry resting seed, which may be taken as exhibiting the most extreme case of functional inertia. The *Hydrocharis* buds when dormant are not only living but are giving manifestations of life, inasmuch as they continue to respire to a slight extent throughout their dormant phase (Terras, *loc. cit.*). In the dry seed we have an organism that is living but is affording no indication of life, inasmuch as it does not respire. If we regard respiration as merely an episode of nutrition (Giglio-Tos, "Les Problemes de la Vie," p. 54; "Trans. Bot. Soc. Edin.," vol. xxii., 1901, p. 45), this non-respiration is what we might expect. That no respiration takes place in the dry seed has been conclusively proved by several interesting experiments by Kochs (Verworn, "Physiology," p. 132); Romanes ("Proc. Roy. Soc.," vol. liv., 1893, p. 335); De Candolle ("Arch. Sc. Phys. et Nat.," viii., '99, p. 517); Brown and Escombe ("Proc. Roy. Soc.," lxii., '97, p. 160); and Thiselton-Dyer ("Proc. Roy. Soc.," lxv., '99, p. 361). Respiration, as Chodat ("Bull. d. Herb. Bois.," vol. iv., 1896, p. 894) points out, "is not a necessary condition of life, but only a condition of its manifestation," for the seed is living although not manifesting life. Even in regard to the manifestation of life, respiration would appear not to be a necessary condition in every case, for, according to Nabokich ("Jour. Roy. Mic. Soc.," 1901, p. 555), it is probable that some seeds can germinate without oxygen. If the air be moist, however, respiration begins, and as the moisture increases the respiration rapidly increases (Kolkswitz, "Ber. Deutsch. Bot. Ges.," xix., 1901, p. 285).

The dry seed may be regarded as an organism whose functional inertia is infinite for any single stimulus, but relatively small for a given combination of stimuli, viz. heat, moisture, and oxygen, and if we add light in certain cases to the combination the response is still further accelerated; for Heinricher ("Ber. Deutch. Bot. Ges.," xvii., 1899, p. 308) finds that seeds of *Veronica peregrina* germinate 5–8 days sooner in daylight than in darkness.

To elicit that manifestation of irritability which we call growth, and which we take as evidence of life in the seed, three tonic stimuli are necessary. Not only must these be applied simultaneously, but they must be applied in the proper intensity. If any one or all the combination be applied in too great intensity, life may be destroyed. On the other hand, there is reason to believe that a single stimulus may be separately applied at an intensity far in excess of the limits, and yet produce no fatal result. In the experiments of Brown and Escombe (*loc. cit.*) seeds were subjected for 110 hours to the temperature of liquid air—183° to −192° C., and in those of Thiselton-Dyer, were immersed for six hours in liquid hydrogen—250°–252° C., and yet germinated. Jencic ("Œster. Bot. Zeit.," li., 1901, p. 268), again, found that when air-dried seeds were subjected to a temperature of −18° C., their germination was accelerated.

The latitude in regard to trespass of the upper cardinal point of temperature appears to be more limited. Dixon ("Nature," lxiv., 1901, p. 256), however, finds that of seeds, specially *Medicago sativa*, exposed for an hour to 110° C., and a further hour to 121° C., 10 per cent. germinate. Jodin ("Compt. Rend.," 129 (1899), p. 893) states when seeds of peas and cress are heated at 60° C. for twenty-four hours, and then for ten hours at 98° C., 30–60 per cent. retain their germinative power; further, these seeds in sealed tubes containing some water-absorbent, such as quicklime, will germinate after being submitted for twenty days to a temperature of 40° C. If we seek in the animal kingdom for cases to parallel the resting seed in its condition of "*vie latente*," or *scheintod*, we find them, perhaps, in the desiccated state of tardigrada and rotifera, and very likely it will be found that these organisms, when thoroughly desiccated, can withstand the same extraordinary tests as the dry seed.

As to the molecular condition of the living matter of the dry seed, little can be said. De Candolle compares it with that of an explosive mixture: so long as the necessary conditions are unapplied the mixture remains quiescent, and will so remain for an indefinite period. Brown and Escombe are of De Candolle's opinion, and hold that the protoplasm has passed from the kinetic to the static condition, and that under such circumstances, the low temperature being maintained, "it is difficult to see why there should be any limit to its perfect stability."

Protoplasm, when manifesting life, contains much water, and desiccation only suspends the vital manifestation, but does not, according to Giglio-Tos (*loc. cit.* p. 101), destroy the living substance. The composition of the molecules remains unaltered because the water does not enter chemically into their constitution, but is only physically held as water of adhesion and of capillarity. The molecular movement ceases because of the absence of the intermolecular water, which serves as the medium of nutritive exchange. This view is essentially the same as that of De Candolle and Brown and Escombe, and according to it the possibilities as to the duration of the latent life of seeds appear very considerable. To this, however, there would appear to be some limit. Gain, *e.g.*, finds ("Comp. Rend.," cxxx., 1900, p. 1643) that in mummy-wheat and barley, while the external appearance and chemical composition of the endosperm are unaltered, the embryo itself has undergone such marked chemical change as to be incapable of germination, and he concludes that the latent life has long ago expired. Of course, it is just possible that the seeds were chemically treated before being put into the mummy-cases by the Egyptians. There is no doubt, however, that seeds may retain their germinative capacity for very considerable periods of time.

Sir William Thiselton-Dyer, in discussing the physiological bearing of his liquid hydrogen experiments on the phenomena of life generally, points out that, if the molecules of living matter be regarded as reduced to the static condition, resting protoplasm is in the condition of an explosive, and there is no criterion whereby to distinguish living matter in the static condition from dead substance.

This would appear to depend on the particular theory held as to living matter. In a purely chemical theory the difficulty is not an insuperable one. The explosive can always be distinguished from the inert mass by applying the proper conditions, just as one chemical substance can be distinguished from another by its reactions to particular tests. On a chemical theory, such as that of Giglio-Tos (*loc. cit.*), the molecule of living matter is distinguished as living because it has a special chemical constitution, in virtue of which it can undergo a specific chemical reaction under certain conditions of environment. Given the necessary internal chemical composition and the necessary external conditions, the chemical reaction follows, externally visible as that manifestation of irritability called growth.

Obituary Notice of the late Charles Stuart, M.D. By Commander F. M. Norman, R.N., Fellow, Botanical Society, Edinburgh.

(Read 10th April 1902.)

Deep and widespread regret was felt throughout the Border district, and in many places beyond its limits, when the death of this much-esteemed medical practitioner took place at his residence—Hillside, Chirnside, Berwickshire,—on 12th February 1902, in the seventy-sixth year of his age. His demise deprived me of an intimate and deeply valued friend of a quarter of a century's duration, and the botanical and horticultural world of one of its chief ornaments and most devoted adherents. Dr. Stuart was "a man—every inch of him," and his cheery welcome, genial presence, manly character, warm, kindly heart, and enthusiasm for Flora could not fail to impress all who had the privilege of his acquaintance. Certainly his departure has created a void in the circle of my own friendships which can never be replaced. He lived a highly useful, blameless, affectionate, Christian life, which, to the great advantage of his family and friends, was prolonged for some years beyond the proverbial "threescore and ten."

Until eighteen months or so before his death he had always enjoyed good health, and his robust frame and excellent constitution showed no signs of breaking till he contracted the ailment which ultimately, after much suffering, laid him low.

Amid many tokens of respect and affection from a large concourse of mourners, he was laid to rest in the